HAMILTON WATCH CO

MILITARY PRODUCTS DIVISION

LANCASTER, PENNSYLVANIA

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FINAL REPORT
FOR
JEWEL BEARING APPLICATION TEST AND ANALYSIS

By
R. G. [illegible]

Contract Number: DA-36-034-ORD-3411 RD

Army Project Number: TN 2-2707

HAMILTON WATCH COMPANY
Military Products Division
Lancaster, Pennsylvania

For

U. S. Army Ordnance Arsenal, Frankford
Philadelphia 37, Pennsylvania
ATTENTION: ORDBA-1610
(Electro-Mechanical
Time Fuze Branch)

JEWEL BEARING APPLICATION
TEST AND ANALYSIS

FINAL REPORT
April 9, 1962

A. OBJECT:

To evaluate the affect on the timer escapement and gear train efficiency as a result of substituting sapphire jewelled bearings for brass at the pinion pivots. Investigate shock resistance of jewelled bearings and determine adequate shock mounting techniques.

B. SUMMARY:

The 225 government-furnished timers were checked for rate on a Gibbs recorder using a 6-1/2 oz-in dead weight drive and were regulated, as required, to produce a two-minute run within the tolerance requirement of the XM-7 Timer.

Concurrent with these preliminary tests, the design was studied and the physical size and shape of the jewels was determined. Final jewel designs are shown on Drawings 21303, 21304, and 21305.

As a basis for comparison, the units to be jewelled were first subjected to ten (10) consecutive timing tests (130 seconds each) and ten (10) consecutive minimum torque tests. The first group was jewelled on original location at the four escapement pivots only. After testing, the results when compared to the control runs indicated no change in timing repeatability, but the minimum driving torque had increased.

Additional testing of jewelled units with the jewels mounted in carefully jig-bored and line-reamed holes also produced inconclusive results.

Sixteen (16) previously jewelled timers were fitted with new escape wheel and pinion assemblies and new lever assemblies. These pivots were burnished to an $\sqrt{8}$ finish and provided an increase in diametral clearance of .0006". The results from the tests on these units were also negative.

At this point, the data to date was reviewed with

the project officer, and it was decided that further testing would be delayed pending his evaluation of this data and a proposal to jewel the lever pallets.

Due to a shift in personnel, a new project officer was assigned and, after a review of the program, it was decided to study the effects of vibration on jewelled timers. Tests on twelve (12) timers before and after transportation vibration indicated that vibration had no adverse effect on timing, minimum operating torque, or condition of the jewels and pivots.

C. **PROCEDURE AND RESULTS:**

Work on this contract started the last week of March 1961 and a comprehensive study of the actual mechanics of jewelling was made. Plate thickness, available space, endshake control, and standardization of jewels were the most important parts of this study. Layouts were made to set up the

actual parameters for the jewel design. The number of different jewels required was found to be four (4); however, by reducing the pivot diameter of one of the pinions, the total was reduced to three (3).

In keeping with the required olive bombe' jewel design and the necessity to control endshake, a modified olive bombe' jewel was required. The design of these jewels is shown on Drawings 21303, 21304, and 21305. These jewels were mounted in reverse to what is customary when used with an endstone, i.e. the spherical surface serves as the bearing surface for the pivot shoulder. The Turtle Mountain Ordnance Plant supplied sapphire jewels to this design but could not supply jewels in glass. Requests to the following three domestic companies were also "no bid":

Richard H. Bird Company
1 Spruce Street
Waltham 54, Massachusetts

Weston Instrument Company
Newark, New Jersey

John Worley Jewel Company
North Falmouth, Massachusetts

Since glass jewels of this design were not available, this requirement of the contract was deleted.

The 225 movement assemblies used in these tests were received on 15 May 1961. Prior to any specific testing, all units were checked for regulation and adjusted as required to produce a full two-minute run in accordance with the requirements of the XM-7 Timer. The tapes from the Gibbs Recorder for these runs were identified with the serial number and retained.

In a conference with the project officer, a plan of testing was decided upon as follows:

1. Timing Test --

   a. Select ten (10) units at random

b. Run ten (10) consecutive timing tests on each unit. Timing period to be one full revolution of an input drive wheel having 30 teeth. This results in three full turns of the 10-tooth number 4 pinion.

c. Record the time (nominal is 130 seconds)

d. Calculate mean time, spread, and standard deviation for each unit.

2. <u>Torque Test</u> --

a. Use the ten timers from the timing test.

b. Make ten (10) consecutive runs on each timer to determine minimum operating torque.

c. Record torque values

d. Calculate mean torque, spread, and standard deviation for each unit.

The test equipment used for these tests is shown in Figures 1 and 2. A mounting block is equipped with a shaft supported by two ball bearings. One end of this shaft is fitted with a 30-tooth gear and the other end is fitted with a pulley whose effective diameter is two (2) inches. A contact button near the outer edge of the pulley actuates a microswitch, thereby, starting the electric timer. Upon the completion of one full revolution, the button again actuates the switch and stops the electric timer. The elapsed time for one revolution of the pulley can then be read on the electric timer. All timing tests were run with a torque of 6-1/2 oz-in. For the torque test, the pulley is replaced by a cam-shaped pulley as shown in Figure 2. This provides a uniformly decreasing torque, and the torque range can be varied by changing the value of the weight "W".

The lubricant used throughout these tests was Hamilton Watch Company fuze oil #3358 which meets

the requirements of Mil-L-11734.

Ten (10) standard timers were tested as described above, and the results of these tests are shown as control tests in Table 1.

These ten (10) timers were then carefully disassembled, marking each gear so that all elements of the train could be reassembled in the same relative position. The two plates containing the pivot holes for the escape arbor and the escape pinion were sent to the model shop for jewelling. The holes were reamed to size on existing location, and the jewels were pressed in place so that the surface controlling endshake was at the same elevation as the plate.

All parts were ultrasonically cleaned, and the timers were reassembled, oiled, and regulated to 81.77 cps.

These jewelled timers were then given timing and torque tests. The results are shown in Table 1

where they can be directly compared with the results on these timers prior to jewelling. The results show that mean minimum driving torque increased for all ten timers and the range of minimum torques increased in nine out of ten cases. However, little or no change was noted in mean time or range of times.

An additional ten timer movements were disassembled and were modified to include jewels in the respective plates for upper and lower pivots of the escape lever and escape pinion. However, these jewels were mounted in accordance with drawing locations instead of matching the existing pivot hole location. Timing and torque tests were conducted on these jewelled movements. These movements were used as a control lot for evaluating the effect of standard pivots versus burnished pivots when jewelled on drawing location. After twenty (20) new escape levers and escape pinions had been burnished to provide a higher surface finish and a pivot diameter reduced by .0006", these movements were

reassembled, and the tests were repeated on nine (9) timers, as shown on Table 3.

The above procedure was repeated on seven (7) of the initially jewelled movements and compared with the original data, as shown on Table 2. Thus, these sixteen (16) timer movements yielded two sets of data, i.e., (1) the effect of burnished pivots operating in jewels on existing location versus standard pivots, and (2) the effect of burnished pivots operating in jewels on drawing location versus standard pivots. Four (4) were left out of these tests due to rejection of reworked lever assemblies. Tables 2 and 3 show the computation of the mean values and range of the time and torque tests. These data show that there is no significant difference between the standard pivots and the burnished pivots whether jewelled on existing location or on drawing location. The values for mean time were all slightly less for the burnished pviots than for the standard pivots. This, by

itself, is not significant since no other pattern was established.

Table 2 shows that movements utilizing burnished pivots require less operating torque than movements which do not contain burnished pivots. Also, the mean time was reduced for six out of seven movements. These data, in Table 2, would indicate, then, that there may be a slight reduction in torque with a smaller variation in timing. This, however, is questionable, and so it was decided by the Frankford Arsenal Project Officer to expose the above movements to the transportation vibration test in accordance with MIL-STD-303 to evaluate the effect of this environment on the jewelled movements. Table 4 shows the data pertaining to this test and indicates that transportation vibration environment had no significant effect on the timing and torque tests. Following these tests, a visual inspection was performed on each movement to verify the condition of the jewels and pivots. The results of this

inspection showed no adverse effects on the jewel mountings nor on the pivots. These jewels were friction fitted or pressed directly into the brass plates with an interference fit of .0002 to .0006 inch.

All the above testing involved jewels mounted at the upper and lower pivots of the escape lever arbor and the escape wheel pinion. All subsequent testing was concerned with evaluating the results of jewelling the upper and lower pivot holes of pinions Nos. 1 thru 4. Prior to reassembly of these movements, the plates were visually inspected to verify that all jewels were flush with the proper side of the plate. These jewels were mounted on the existing pivot hole location. After these movements were assembled and regulated, timing and torque tests were run before and after exposure to the transportation vibration environment.

Reference to Table 5 shows the set of computed data for each of the three test conditions: (1) the

control runs on the standard movements; (2) the test runs on the jewelled movements before transportation vibration; and (3) the test runs after transportation vibration. Again, there was no significant development in data from one test condition to another. The values for mean time seemed to hold fairly consistent while the mean torque values all decreased slightly for the jewelled units with the exception of one (#1188). After transportation vibration, these mean torque values experienced another slight decrease with one exception (#1090) which would serve to indicate that jewelling is not a significant factor.

D. CONCLUSIONS:

In the summary of work, it has already been indicated that the results of jewelling all pivot points had no significant effect on the performance of the timer movements. However, since each of the mean values recorded in the tables of data were

based on only ten runs each, it is therefore difficult to predict, on the basis of these test results, how much the operating life was increased. It is reasonable to assume that pivot life and pivot hole sizes could be maintained over a greater number of operating cycles, especially the heavier loaded pivots.

This particular escapement was originally designed as a "one-shot-and-done" device and as such was not intended for repeated testing. Further, due to the laminated design and the fact that some latitude for relative movement of plates exists, when the assembly screws are loose, makes "before and after" test results somewhat unsatisfactory for comparative purposes. This is especially so in the small numbers involved in this series of tests. Past experience with this same movement has shown that the simple act of loosening the nuts on the assembly screws and then tightening them again will invariably require a slight

readjustment to bring it back into time.

It is, therefore, concluded that in order to materially improve this timer, one or more of the following changes would have to be made:

1. Tighter controls on hole locations.

2. Better finishes on holes and pivots.

3. Reduced friction between escape wheel teeth and pallet faces.

4. More positive location of plates relative to each other at assembly.

5. Better finish on gear and pinion teeth.

6. Closer control on gear and pinion concentricity.

E. RECOMMENDATIONS:

Due to the high interest of the Hamilton Watch Company in the continued improvement and use of the Junghan's Escapement, many paper studies, as well as hardware experimentation, have been made. Some of these, such as the beryllium copper escape wheel, have resulted in improved life and operation. The following analysis was made to show that the pivot friction of the escape lever arbor is a small percentage of the friction between the escape wheel teeth and the pallet as each pallet face moves through the "lock" position.

Reference to Figure 3 shows the frictional forces acting at the arbor pivot and the pallets when each pallet is shown entering the "lock" position. These same frictional forces are also acting, but in the opposite direction, when the pallets are withdrawing from the "lock" position.

Following is an estimated value of the frictional drag on the lever as the leading corner of the

escape wheel tooth comes in contact with the lock surface of the exit pallet "B".

The torque T_{EW} at the escape wheel is:

$$T_{EW} = \frac{T_M}{R} E$$

where T_M is the mainspring torque.

R is the overall gear train ratio from mainspring arbor gear to escape wheel pinion.

E is the estimated gear train efficiency

then the force F required to resist the escape wheel torque is:

$$F = \frac{T_{EW}}{r_b}$$

where r_b is the radial distance from the escape wheel pivot to the base circle of the tooth and

the normal force F_n of the wheel tooth against the pallet is:

$$F_N = \frac{F}{\cos\theta}$$

then $F_L = u F_n$ where u is the coefficient of friction between the wheel tooth and the pallet "B".

Therefore, the retarding torque T_r acting on the pallet is $T_r = F_L R$.

Following is an estimated value of the frictional drag on the lever as a result of pivot friction.

Use the same value for F_n as above.

Then the drag force F_p at both upper and lower lever pivots is:

$$F_p = 2\mu F_n$$

where μ is the coefficient of friction between the arbor pivots and the brass plates.

Therefore, the retarding torque acting at the lever pivots is:

$$T_P = F_P r$$

If the coefficient of friction μ is the same between the wheel teeth and the pallet as it is between the lever pivots and the plates, then the frictional drag forces F_L and F_P will be equal.

The the ratio of $\frac{T_L}{T_P}$ is:

$$\frac{T_L}{T_P} = \frac{R_L R}{2F_P r} = \frac{R}{2r} = \frac{.071}{2(.0094)} = 3.78$$

This equation states that the lever drag at the pallet as a result of friction is 3.78 times greater than the drag on the lever as a result of pivot friction.

In line with the results of the above analysis, a design for jewelling the pallets of a Junghans's Escapement was laid out and the necessary changes

to existing parts as well as new parts were detailed. This design is shown on SK 1228 and SK 1230.

It is highly recommended that any future work directed toward improving this particular type of timer include an investigation of this approach.

Contract ORD-3411 RD
Final Report

April 1962

F. DISTRIBUTION LIST:

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Hamilton Watch Company		
Donald K. Sites	1	1
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APPENDIX I

Table 1

Unit No.	Control Tests on Standard Pivots: Time, Mean	Second Range	Torque Mean	Oz-In Range	Jewelled At Escape Lever & Wheel Existing Location: Time, Mean	Second Range	Torque Mean	Oz-In Range
0517	129.973	.114	1.961	.237	130.017	.132	3.816	.662
1136	129.988	.097	2.179	.310	129.524	.192	3.823	.836
0522	129.827	.213	2.795	.124	129.720	.207	3.610	.286
0504	130.014	.053	2.739	.455	130.046	.323	4.093	1.063
0539	129.945	.060	2.392	.501	129.920	.139	3.453	.339
0457	130.105	.066	2.957	.423	136.176	.210	6.055	.759
0570	130.035	.053	3.213	.513	130.510	.074	3.518	1.624
0590	130.025	.084	2.328	.488	129.986	.095	3.623	.582
1098	129.501	.044	2.845	.391	129.981	.386	3.504	.550
1145	129.549	.076	2.712	.508	130.059	.087	3.357	.841

APPENDIX I

Table 2

Unit No.	Jewelled on Existing Location *				Jewelled on Existing Location Burnished Pivots *			
	Time, Second Mean	Time, Second Range	Torque, Oz-In Mean	Torque, Oz-In Range	Time, Second Mean	Time, Second Range	Torque, Oz-In Mean	Torque, Oz-In Range
0517	130.017	.132	3.816	.662	129.655	.084	3.759	.471
1136	129.524	.192	3.823	.836	129.782	.291	2.378	.205
0539	129.920	.139	3.453	.339	129.451	.138	3.203	.418
0457	130.176	.210	6.055	.759	129.567	.212	4.455	.259
0590	129.986	.095	3.623	.582	129.690	.094	4.168	.712
1098	129.981	.386	3.504	.550	129.559	.173	2.997	.566
1145	130.059	.087	3.357	.841	129.788	.056	3.272	.439

* Jewelled at Escapement Pivots only

APPENDIX I

Table 3

Unit No.	Jewelled on Drawing Location *				Jewelled on Drawing Location Burnished Pivots *			
	Time, Second		Torque, Oz-In		Time, Second		Torque, Oz-In	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
0543	129.930	.131	3.567	.397	129.186	.579	2.724	.290
1085	130.024	.374	3.658	.629	129.690	.439	2.271	.705
1092	129.938	.286	3.236	1.121	129.840	.303	3.150	.430
1100	129.815	.245	3.228	.381	129.570	.093	3.183	.257
1118	129.860	.244	2.628	1.111	129.308	.139	3.340	.410
1148	129.765	.136	3.849	.646	129.531	.206	2.404	.413
1149	129.992	1.047	3.309	.789	129.894	.068	3.031	.390
1176	129.791	.257	3.098	.471	129.151	.440	4.194	.935
1213	129.734	.184	2.978	.281	129.554	.154	2.991	.298

* Jewelled at Escapement Pivots only.

APPENDIX I

Table 4

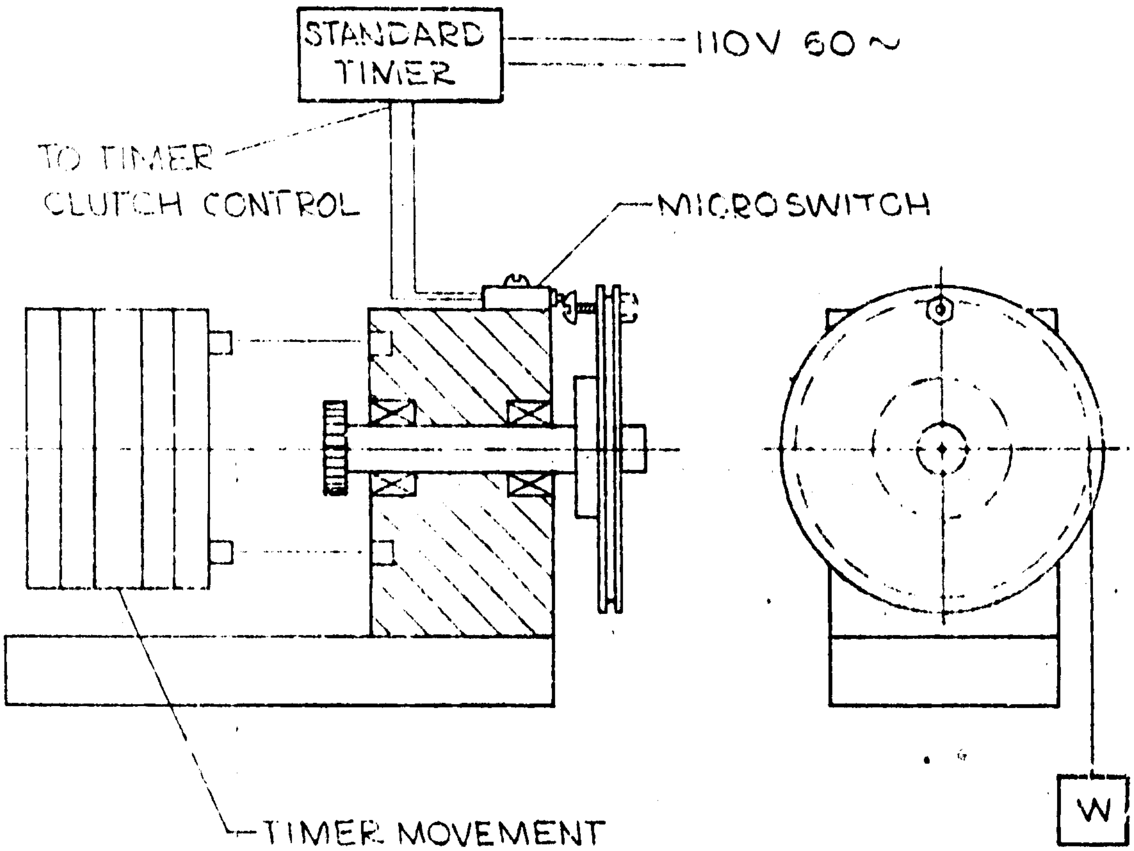
Unit No.	BEFORE Transportation Vibration Existing Location - Burnished Pivots*				AFTER Transportation Vibration Existing Location - Burnished Pivots*			
	Time, Second		Torque, Oz-In		Time, Second		Torque, Oz-In	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
0517	129.655	.084	3.759	.471	129.571	.034	4.318	.44
1136	129.782	.291	2.378	.205	129.607	.175	2.574	.36
0539	129.451	.138	3.203	.418	129.446	.181	2.875	.35
0457	129.567	.212	4.455	.259	129.095	.124	3.296	.50
0590	129.690	.094	4.168	.712	129.654	.082	4.968	.19

* Jewelled at Escapement Pivots only.

APPENDIX I

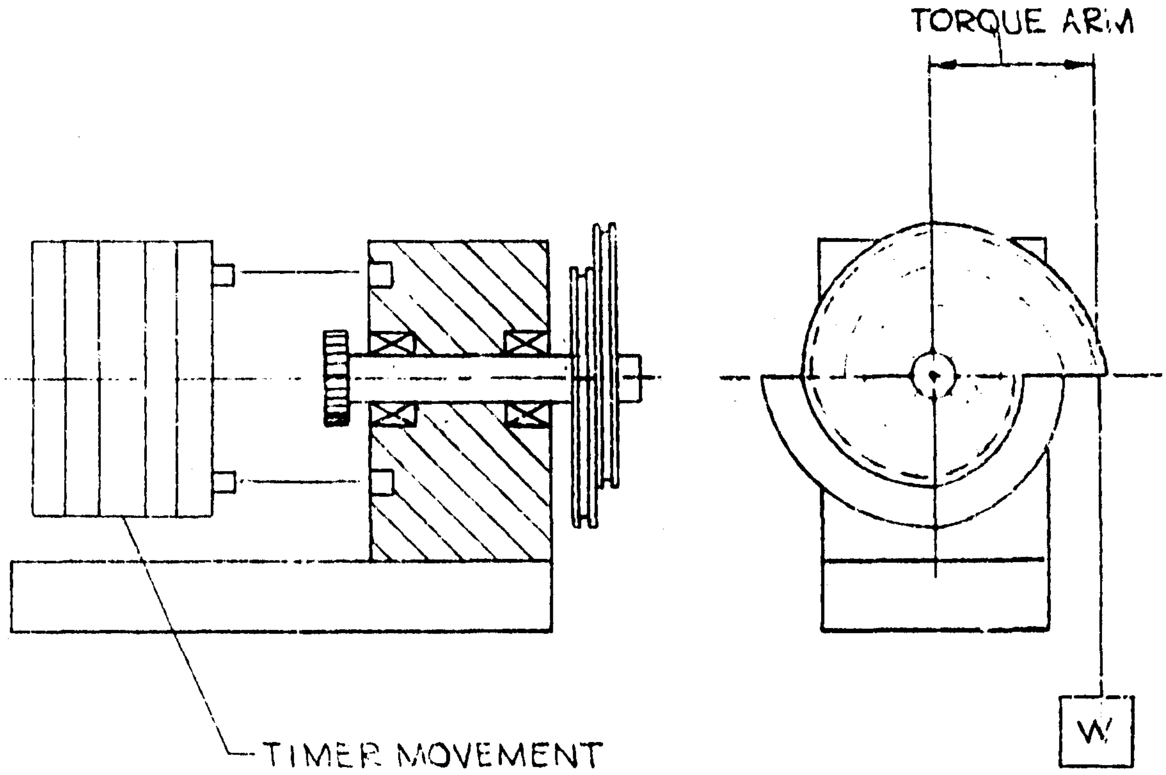
Table 5

Unit No.	CONTROL TESTS Time, Second Mean	CONTROL TESTS Time, Second Range	CONTROL TESTS Torque, Oz-In Mean	CONTROL TESTS Torque, Oz-In Range	Jewelled At Pivots #1, #2, #3, and #4 — BEFORE Transportation Vibration Existing Location: Time, Second Mean	Range	Torque, Oz-In Mean	Range	Jewelled At Pivots #1, #2, #3, and #4 — AFTER Transportation Vibration Existing Location: Time, Second Mean	Range	Torque, Oz-In Mean	Range
0475	130.080	.123	3.217	.218	130.612	.095	2.096	.273	130.498	.336	1.899	.744
1090	130.286	.376	3.643	.486	130.128	.082	1.014	.056	130.134	.176	3.556	.497
1119	129.393	.191	3.842	.377	129.774	.086	2.423	.273	129.711	.113	2.396	.222
1152	129.187	.313	4.029	.494	129.589	.127	3.668	.328	129.418	.136	3.595	.295
1167	128.894	.346	3.724	.480	129.362	.162	2.352	.380	129.337	.437	2.278	.526
1188	130.067	.134	3.333	.205	129.788	.105	3.663	.328	129.830	.139	3.531	.331
1209	130.885	.307	3.840	.627	130.097	.265	3.371	.270	130.032	.223	2.529	.587
1212	129.973	.167	3.403	.247	129.513	.174	2.391	.162	129.577	.251	2.212	.190



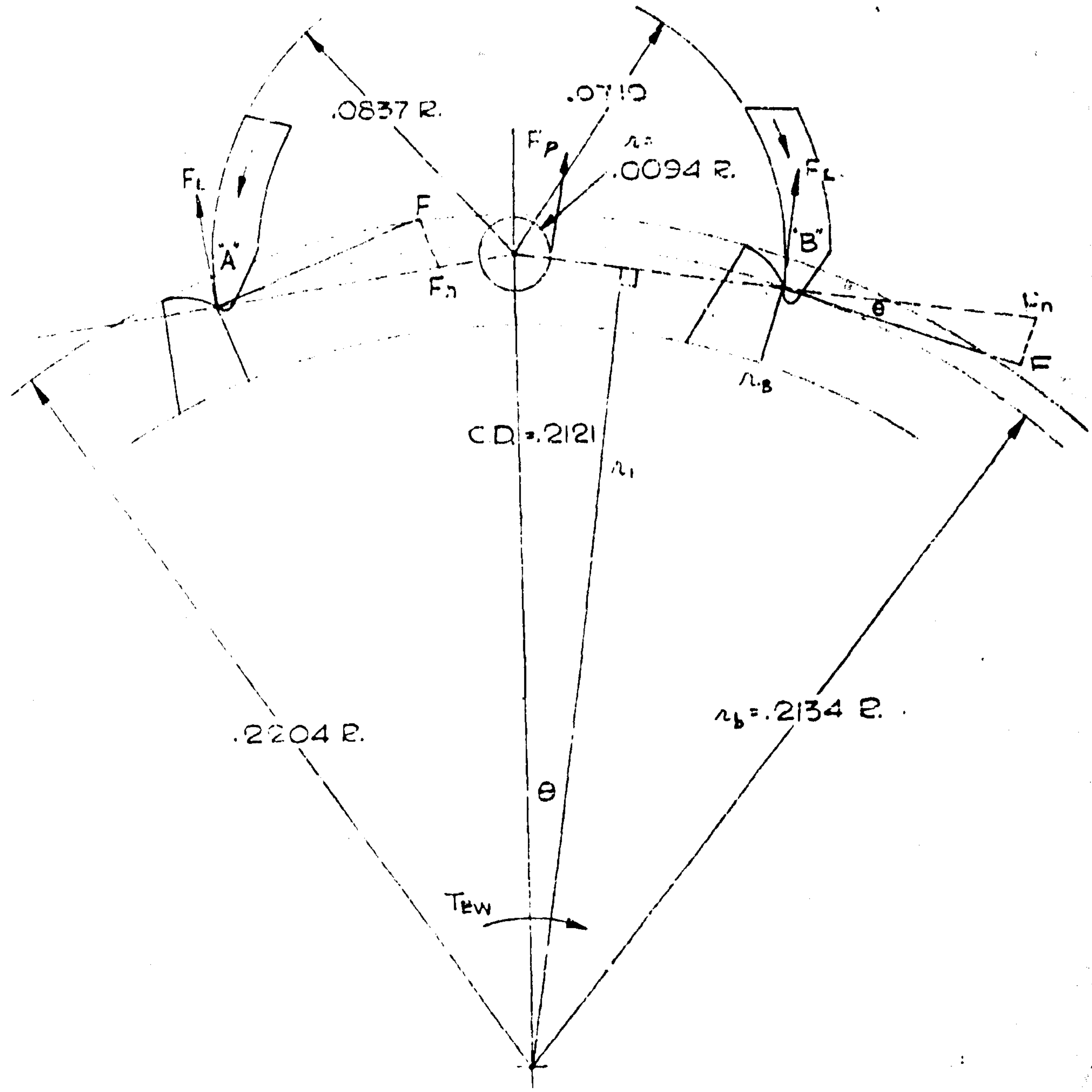
DATE 6 APR 62	SCALE	TIMING TEST FIXTURE	DWG. NO. FIG. 3
DRAFTSMAN EFF	CHECKER		
ENGR	APPROVAL		SHEET OF

MILITARY PRODUCTS DIV., HAMILTON WATCH CO., LANCASTER, PA



DATE 9 APR 62	SCALE —	MINIMUM TORQUE TEST FIXTURE	DWG. NO. FIG. 2
DRAFTSMAN EFP	CHECKER		
ENGR	APPROVAL		SHEET OF

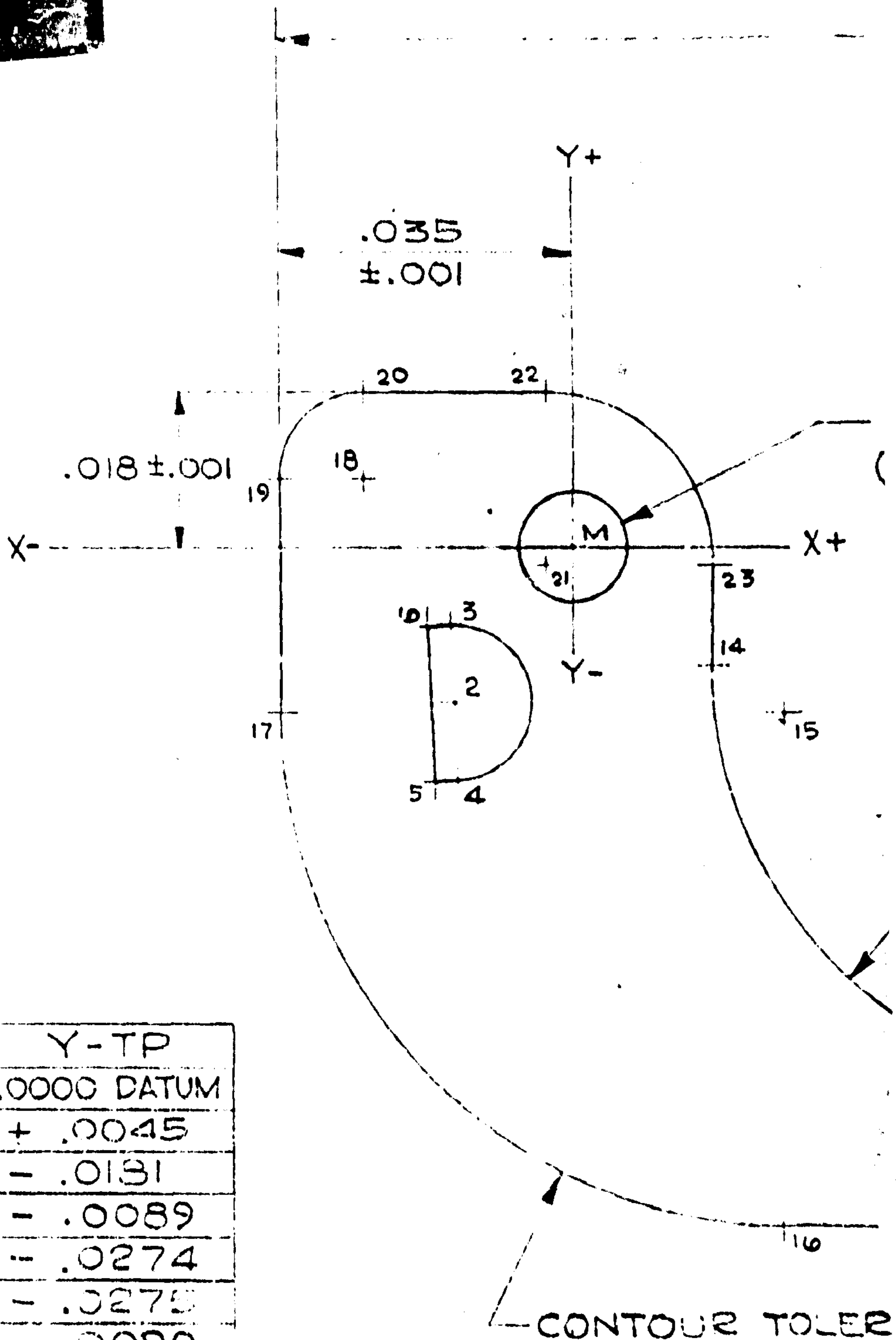
MILITARY PRODUCTS DIV., HAMILTON WATCH CO., LANCASTER, PA.



DATE 28 SEP 59	SCALE 25/1	LAYOUT OF ESCAPEMENT WHEEL TEETH AND PALLETS FOR FRICTION ANALYSIS	DWG. NO. FIG 3
DRAFTSMAN PKS	CHECKER		
ENGR	APPROVAL		SHEET OF

MILITARY PRODUCTS DIV., HAMILTON WATCH CO., LANCASTER, PA

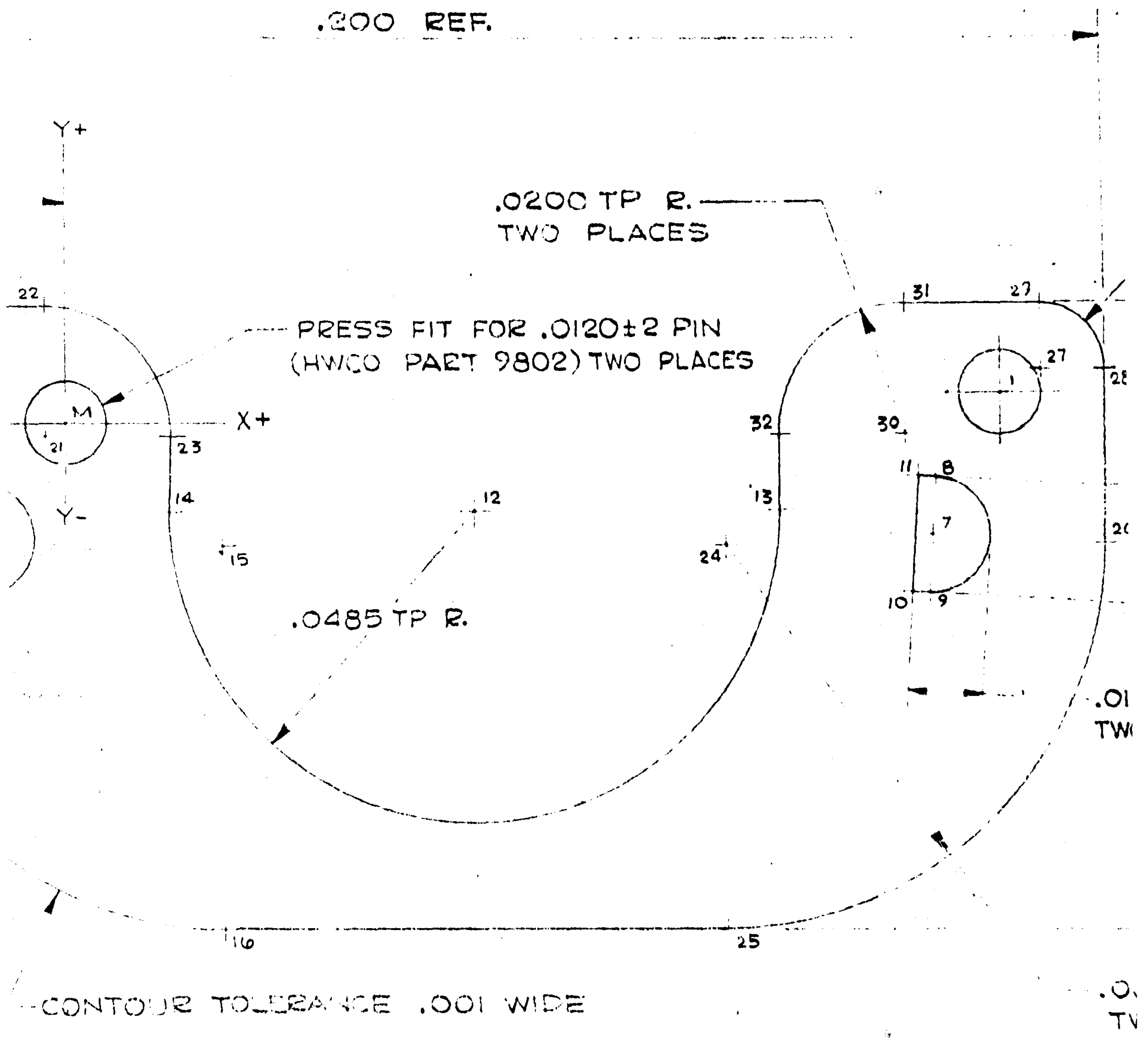
4 3



C

POSN	X - TP	Y - TP
M	.0000 DATUM	.0000 DATUM
1	+.1485 DATUM	+ .0045
2	- .0156	- .0131
3	- .0161	- .0089
4	- .0151	- .0274
5	- .0176	- .0275
6	- .0186	- .0090
7	+ .1377	- .0182
8	[illegible]	[illegible]

2

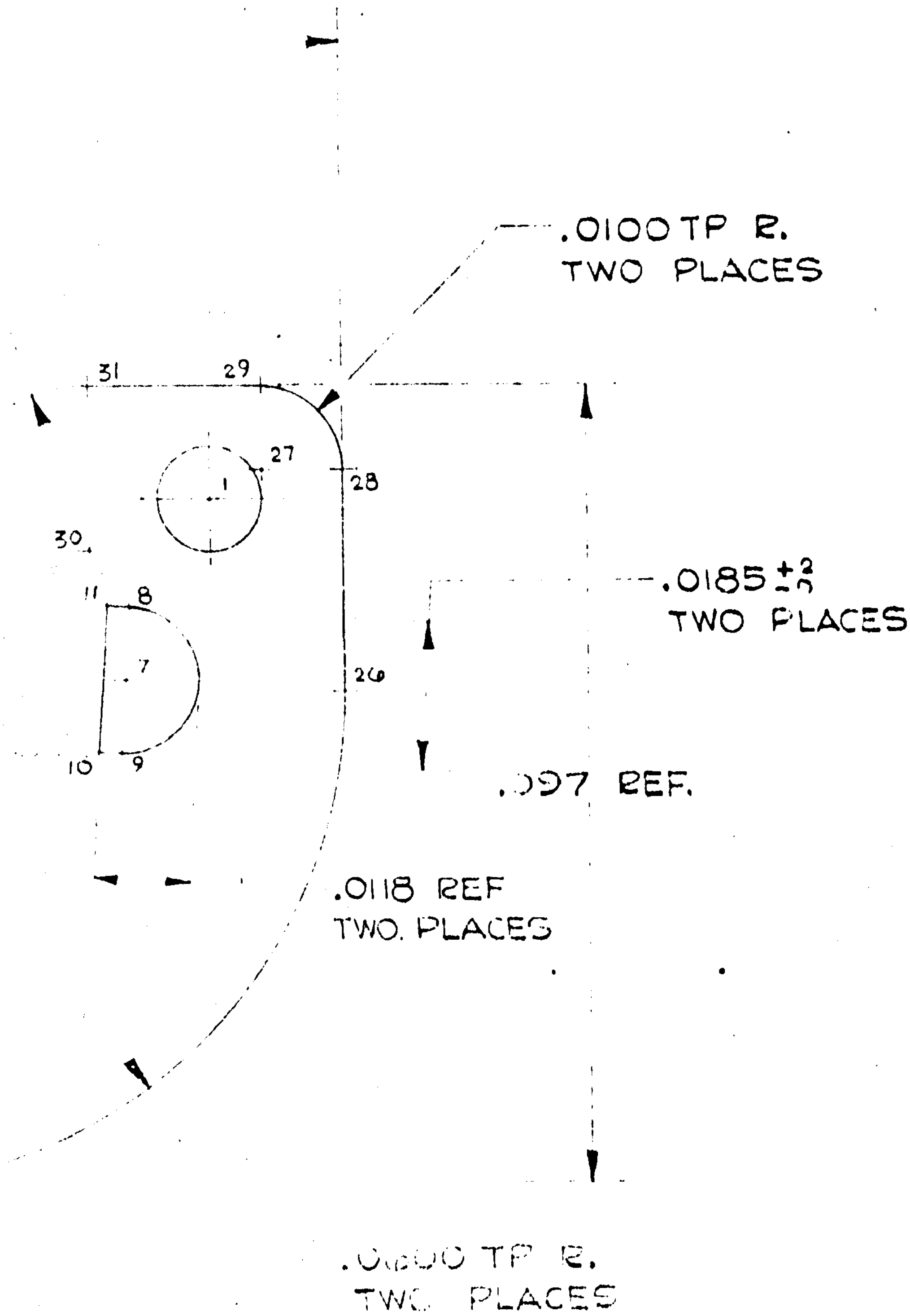

.200 REF.
Y+
.0200 TP R.
TWO PLACES
PRESS FIT FOR .0120±2 PIN
(HWCO PART 9802) TWO PLACES
X+
Y-
M
.0485 TP R.
CONTOUR TOLERANCE .001 WIDE

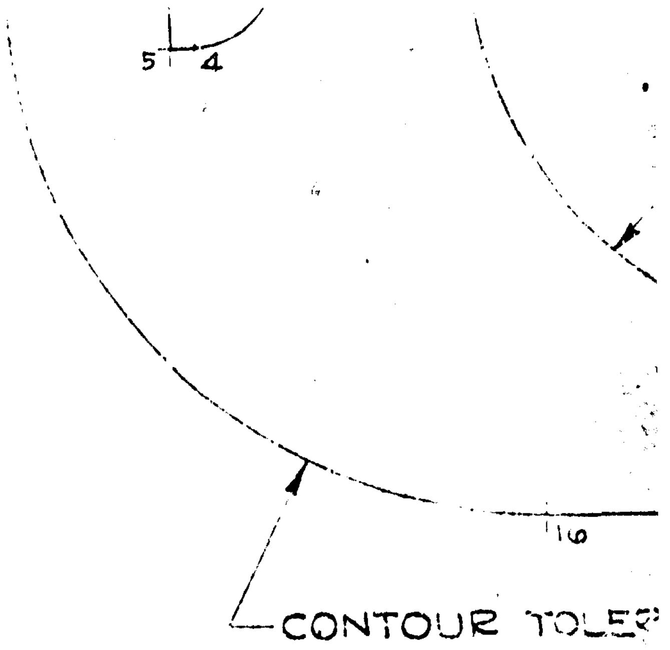
2

1

REVISIONS						
ZONE	SYM	BY	DESCRIPTION	DATE	CHKD	APPD

3





POSN	X - TP	Y - TP
M	.0000 DATUM	.0000 DATUM
1	+.1485 DATUM	+ .0045
2	- .0156	- .0181
3	- .0161	- .0089
4	- .0151	- .0274
5	- .0176	- .0275
6	- .0186	- .0090
7	+ .1377	- .0182
8	+ .1382	- .0090
9	+ .1372	- .0275
10	+ .1347	- .0274
11	+ .1357	- .0089
12	+ .0650	- .0140
13	+ .1135	- .0140
14	+ .0165	- .0140
15	+ .0250	- .0190
16	+ .0250	- .0790
17	- .0350	- .0190
18	- .0250	+ .0080
19	- .0350	+ .0080
20	- .0250	+ .0180
21	- .0035	- .0020
22	- .0035	+ .0180
23	+ .0165	- .0020
24	+ .1050	- .0190
25	+ .1050	- .0790
26	+ .1650	- .0190
27	+ .1550	+ .0080
28	+ .1650	+ .0080
29	+ .1550	+ .0180
30	+ .1335	- .0020
31	+ .1335	+ .0180
32	+ .1135	- .0020

NOTES:

1. HOLE 1 & POSN 2

2. POSN 12 THRU 32

3. TWO(2) REQD. PER

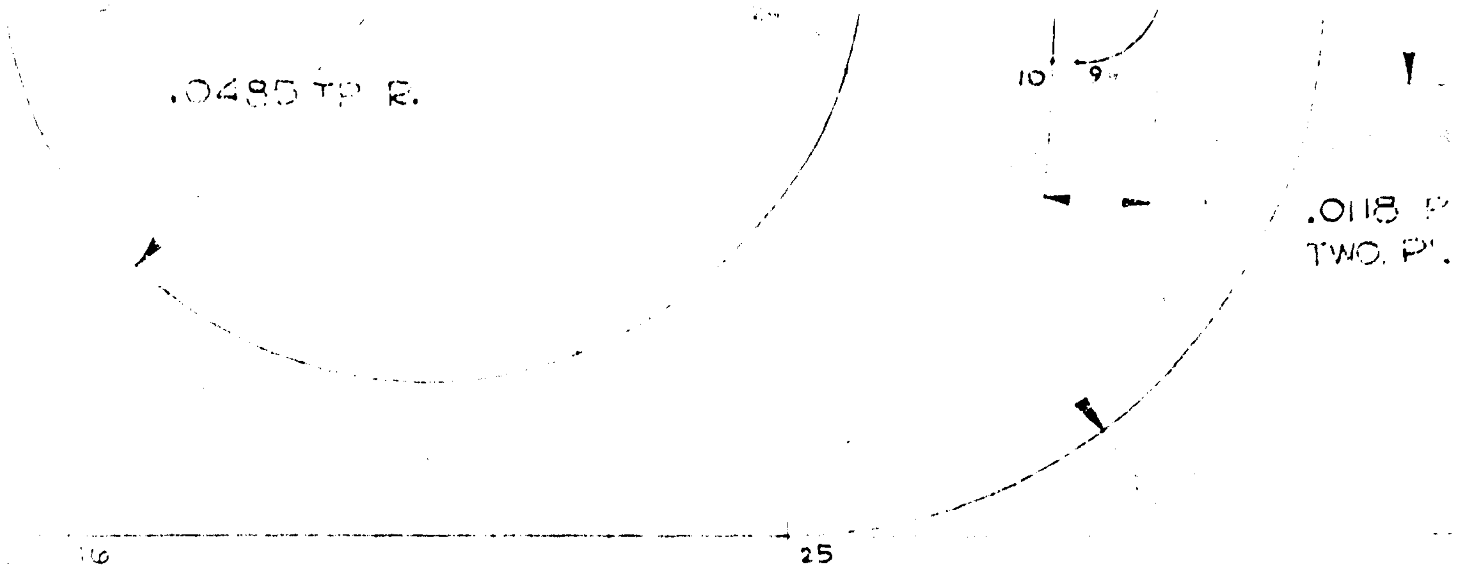
B

A

4

4

3



TOUR TOLERANCE .001 WIDE

& POSN 2 THRU 11 $\boxed{\oplus\ .0006\ \text{DIA}}$

2 THRU 32 $\boxed{\oplus\ .0014\ \text{DIA}}$

REQD PER UNIT

5

REQD	PART NO	DESCRIPTION

MATERIAL .020

HEAT TREATMENT

NEXT ASSY | USED ON

APPLICATION

FINAL PROTECTIVE

DIMENSIONS ARE IN INCHES

UNLESS OTHERWISE SPECIFIED

TOLERANCES SURFACE FINISH

ANGLES ±

DECIMALS ±

FRACTIONS ±

MILI

HA

3 | 2

.097 REF.

.018 REF
TWO PLACES

.0600 TP R.
TWO PLACES

E

6

ART NO	DESCRIPTION	STOCK SIZE	MATL	MATL SPEC	REV	ZONE

LIST OF MATERIAL

MATERIAL .020 BRASS

HEAT TREATMENT

FINAL PROTECTIVE FINISH

DATE 5/31/61

DRAFTSMAN BES

CHECKED RPL

ENGR

ENGR

APPROVAL

ADAPTER,
ESCAPEMENT LEVER

A

Y USED ON

PLICATION

ONS ARE IN INCHES

THERWISE SPECIFIED

SURFACE FINISH

MILITARY PRODUCTS DIV.,
HAMILTON WATCH CO.,
LANCASTER, PA.

SCALE 50/1

UNIT WT.
ACT. CALC.

DWG SIZE C 7x22

DRAWING NO. SK 1228

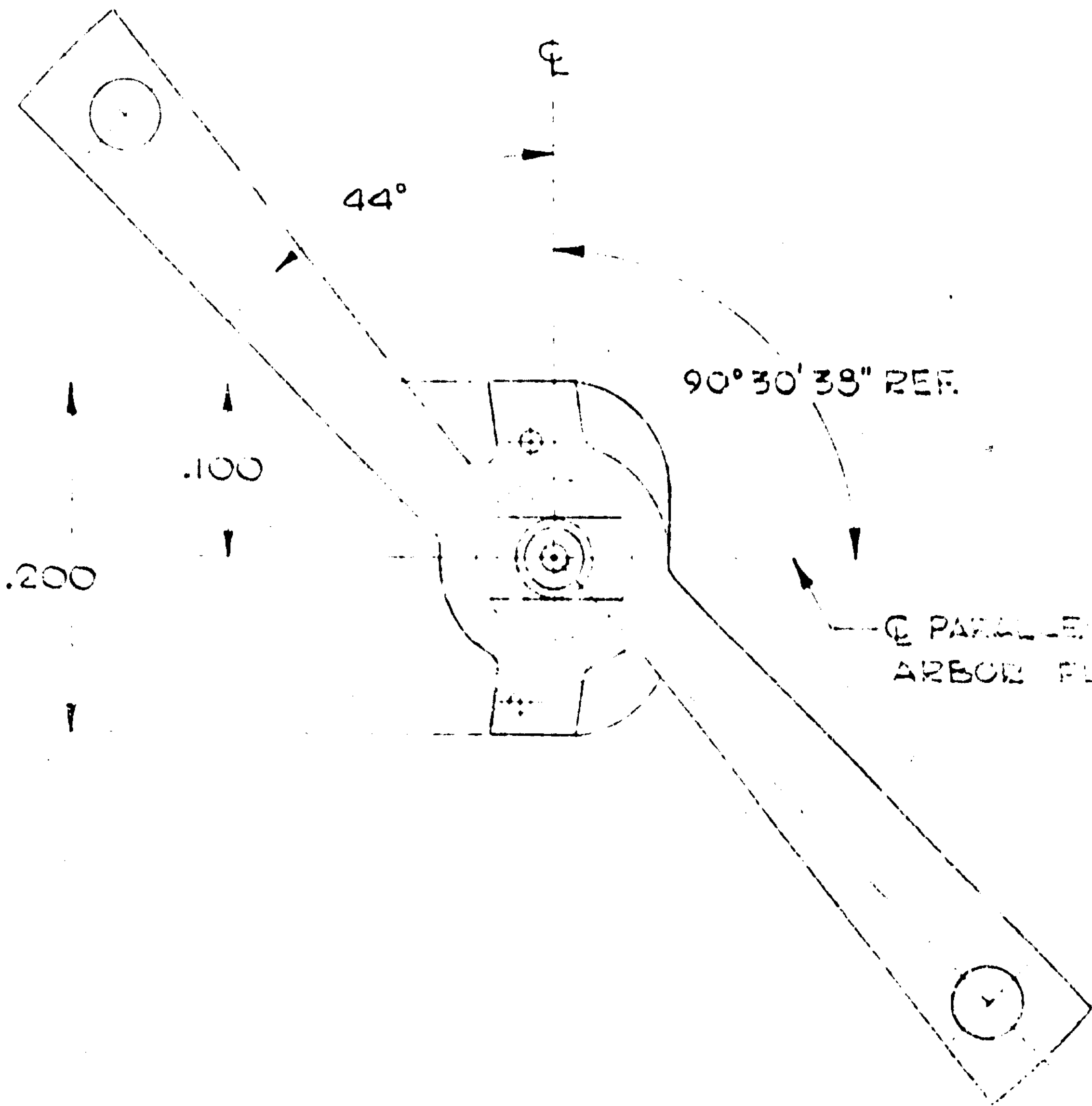
SHEET OF

REV.

2

1

4 3

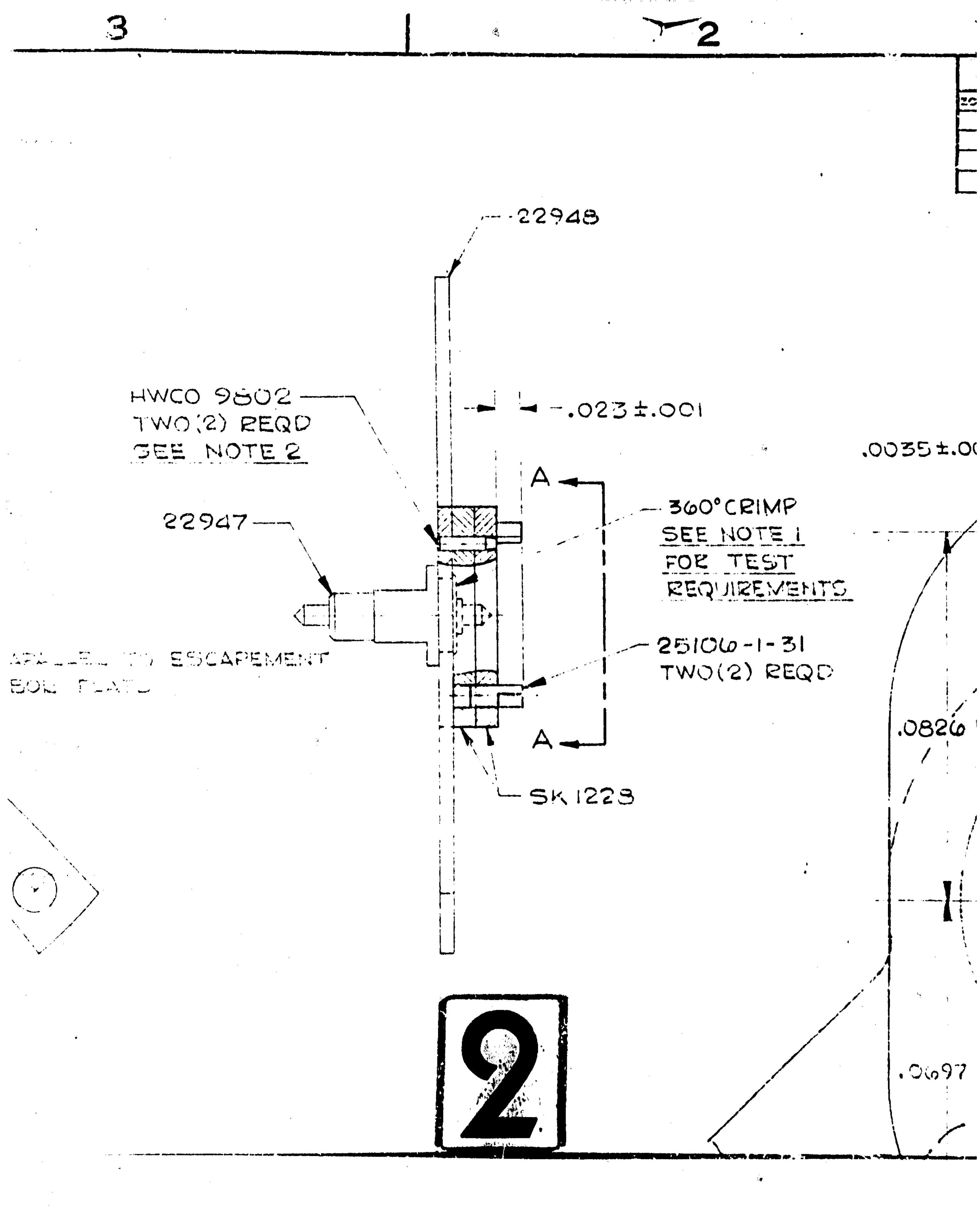


HWCD
TWO
SEE

229

C

NOTES:



3
2
22948
HWCO 9802
TWO (2) REQD
SEE NOTE 2
.023±.001
.0035±.0
A
360°CRIMP
SEE NOTE 1
FOR TEST
REQUIREMENTS
22947
ESCAPEMENT
25106-1-31
TWO(2) REQD
A
.0826
SK 1228
.0697
2

2 1

3

REVISIONS

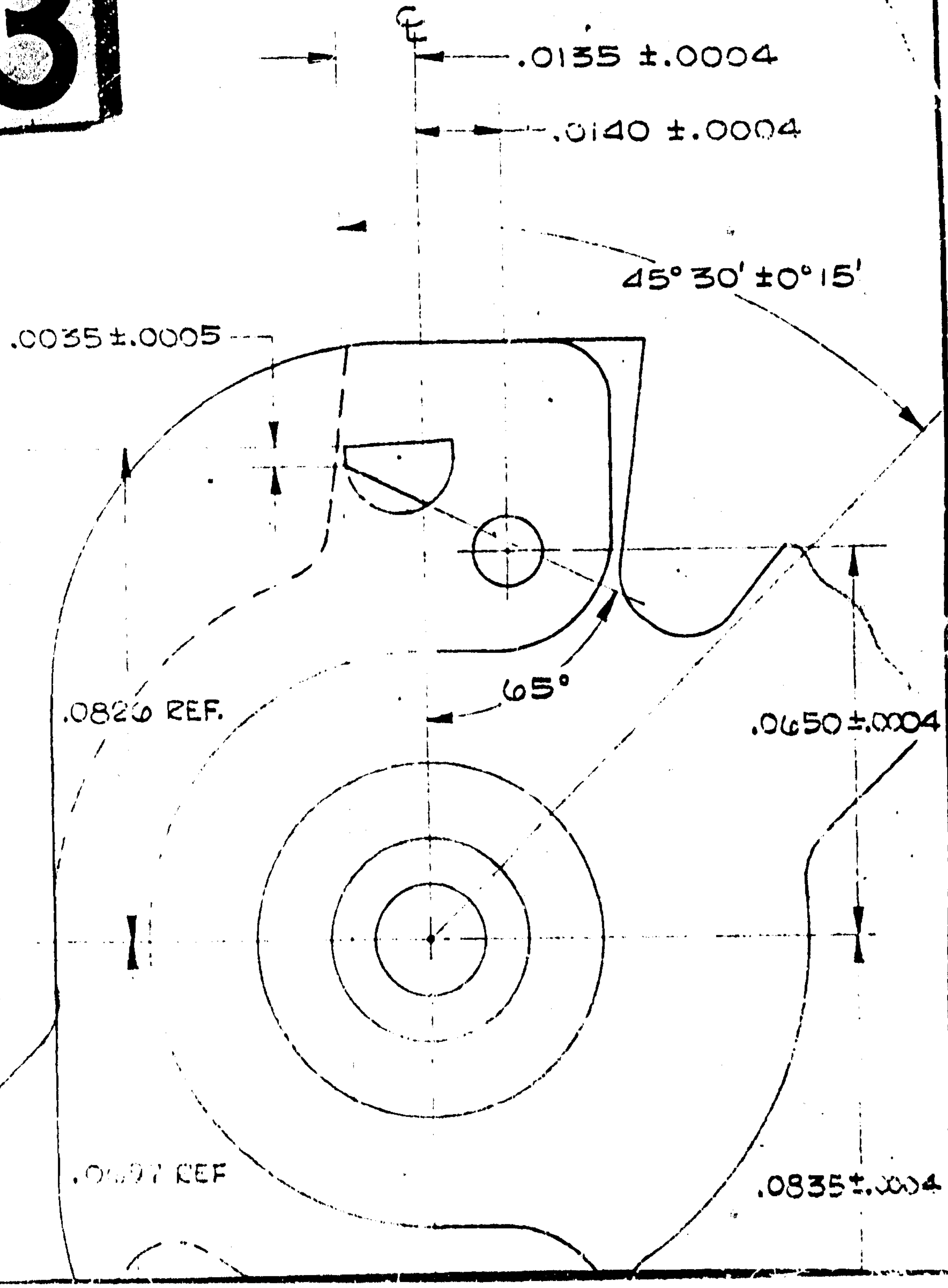
ZONE	SYM	BY	DESCRIPTION	DATE	CHKD	APPD

D

±.001

360° CRIMP
SEE NOTE 1
FOR TEST
REQUIREMENTS

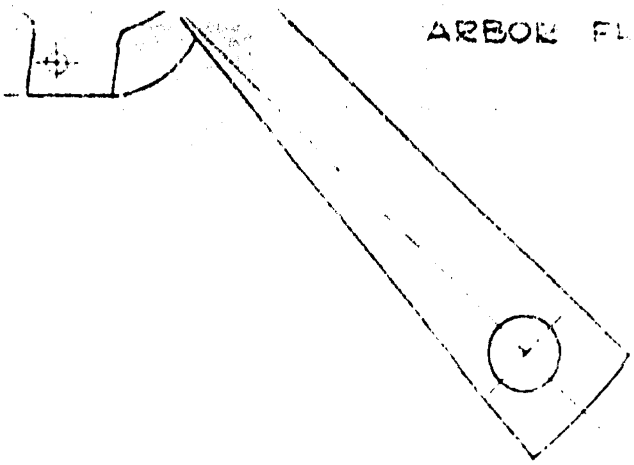
-25106-1-31
TWO (2) REQD



C

ARBOR FLAT

C



B

NOTES:

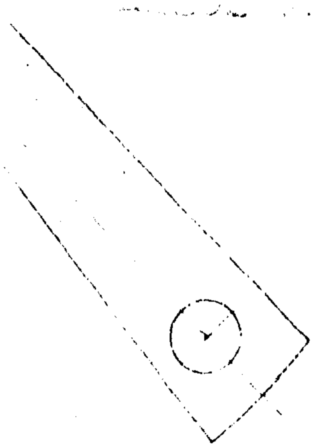
1. ASSEMBLY MUST WITHSTAND A STATIC LOAD
   AND .1 INCH LBS. OF TORQUE
2. PINS TO BE PRESS FITTED FLUSH WITH BO

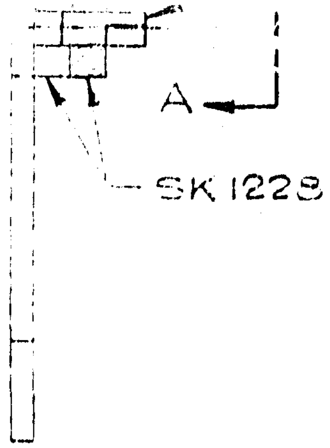
A

4

4

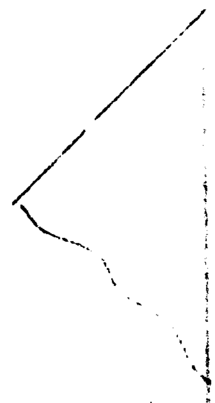
3





A STATIC LOAD OF 8.5 LBS.

FLUSH WITH BOTTOM OF LEVER



.0

VIE

SCA

2	9802	PIN,	02
2	25106-1-31	FIN,	6-1-
2	SK 1228	ADAP	228
1	22948	LEVE	8
1	22947	ARBO	47
REQD	PART NO		T NO

5

NEXT ASSY	USED ON
APPLICATION	

ICATI

DIMENSIONS ARE IN INCHES

UNLESS OTHERWISE SPECIFIED

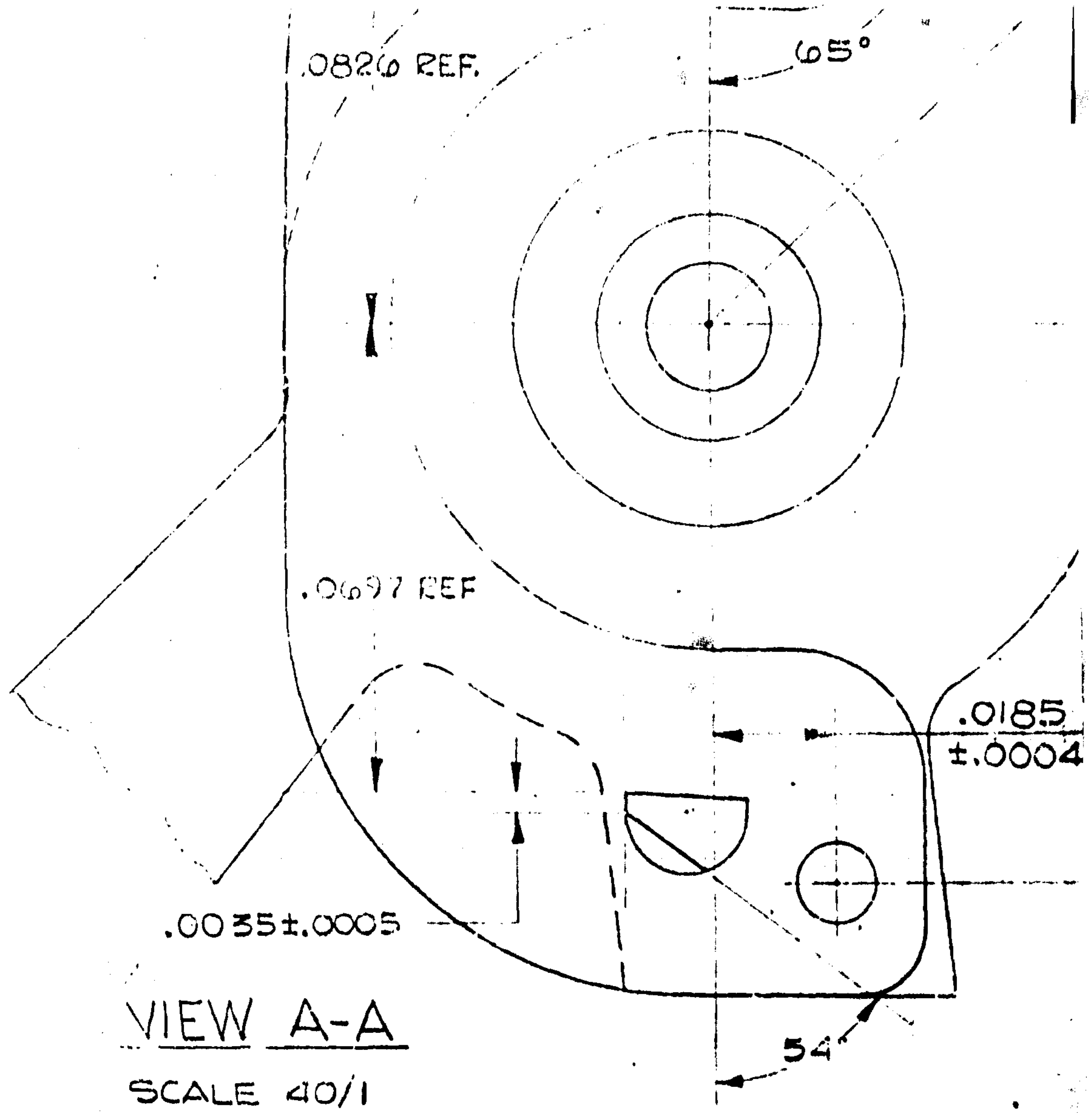
TOLERANCES — SURFACE FINISH

ANGLES ± 1°

DECIMALS ± .001

FRACTIONS ± /

3 — 2



VIEW A-A

SCALE 40/1

2	9802	PIN, MINUTE	HWCO PART		
2	25106-1-31	PIN, JEWEL	HWCO PART		
2	SK 1228	ADAPTER, LEVER			
1	22948	LEVER (MODIFIED)			
1	22947	ARBOR			
REQD	PART NO	DESCRIPTION	STOCK SIZE	MATL	MATL

LIST OF MATERIAL

NEXT ASSY	USED ON	MATERIAL	DATE 5/31/61
		HEAT TREATMENT	DRAFTSMAN BE
			CHECKER RPL
			ENGR
			ENGR
			APPROVAL

APPLICATION

DIMENSIONS ARE IN INCHES

FINAL PROTECTIVE FINISH

UNLESS OTHERWISE SPECIFIED

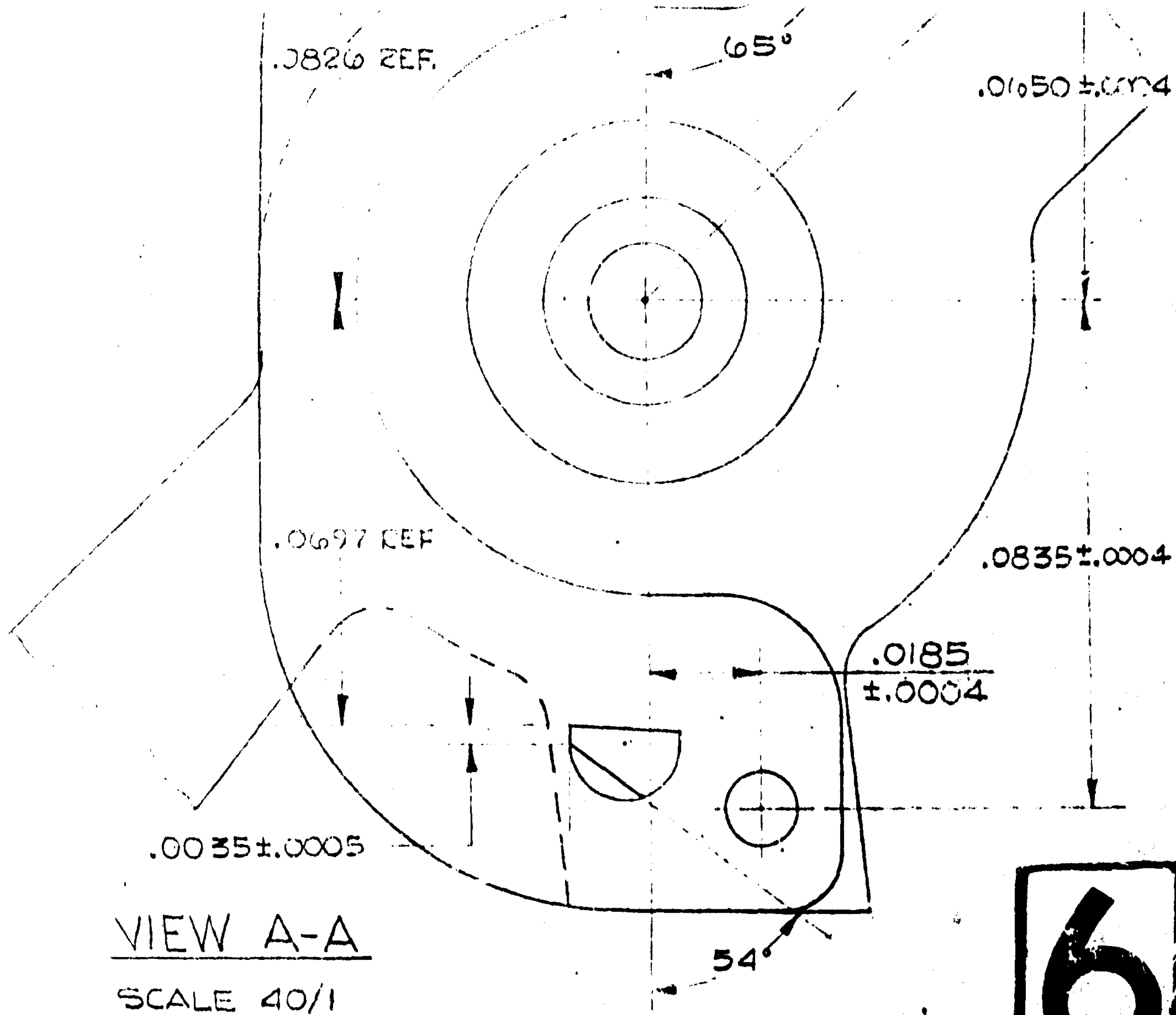
TOLERANCES — ANGLES ± 1 — DECIMALS ± — FRACTIONS ±

SURFACE FINISH √

MILITARY PRODUCTS DIV.,
HAMILTON WATCH CO.,
LANCASTER, PA.

ESCAPEMENT SUB-ASSY (MO

SCALE 10/1 — UNIT WT. ACT. CALC. — DWG SIZE C 17422 — DRAWING N SK — SHEET



VIEW A-A

SCALE 40/1

6

PART NO	DESCRIPTION	STOCK SIZE	MATL	MATL SPEC	REV	ZONE
802	PIN, MINUTE	HWCO PART				
106-1-31	PIN, JEWEL	HWCO PART				
1228	ADAPTER, LEVER					
948	LEVER (MODIFIED)					
947	ARBOR					

LIST OF MATERIAL

MATERIAL	DATE 5/31/61
	DRAFTSMAN BE
HEAT TREATMENT	CHECKER RPL
	ENGR
FINAL PROTECTIVE FINISH	ENGR
	APPROVAL

ESCAPEMENT LEVER
SUB-ASSY (MODIFIED)

SSY | USED ON

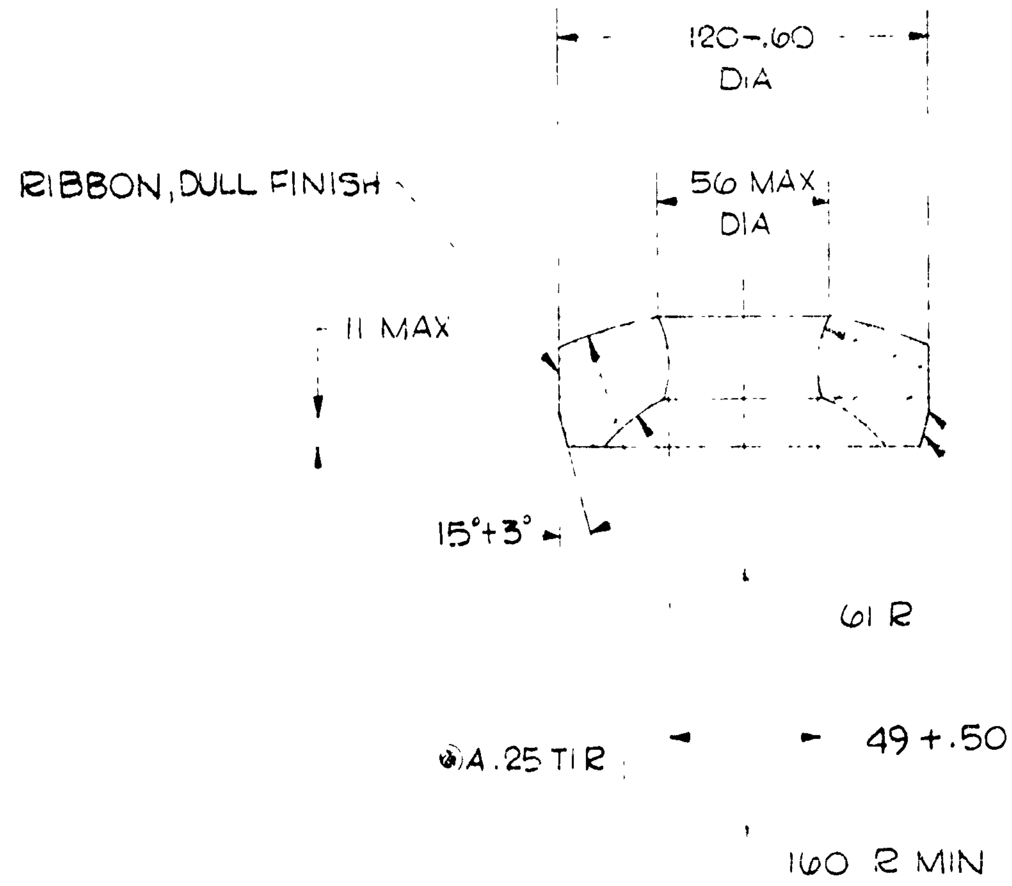
APPLICATION

DIMENSIONS ARE IN INCHES
OTHERWISE SPECIFIED
TOLERANCES: ±1° ±.001 ± /
SURFACE FINISH √

MILITARY PRODUCTS DIV.,
HAMILTON WATCH CO.,
LANCASTER, PA.

SCALE 10/1
UNIT WT. ACT. CALC.
DWG SIZE C
17.02
DRAWING NO. SK 1230
SHEET OF
REV.

JEWEL	MATERIAL
A	SYNTHETIC SAPPHIRE
B	GLASS



NOTE

1. ALL DIMENSIONS ARE IN .01 MM
2. ALL SURFACES TO BE POLISHED EXCEPT WHERE OTHERWISE NOTED
3. OLIVE HOLE TO BE FREE OF ANY CHIPS OR SCRATCHES VISIBLE WITH AN 18X EYEGLASS

1

REQD	PART NO
NEXT ASSY	
APPLICA	

DIMENSIONS AR

UNLESS OTHERW

TOLERANCES

ANGLES ±

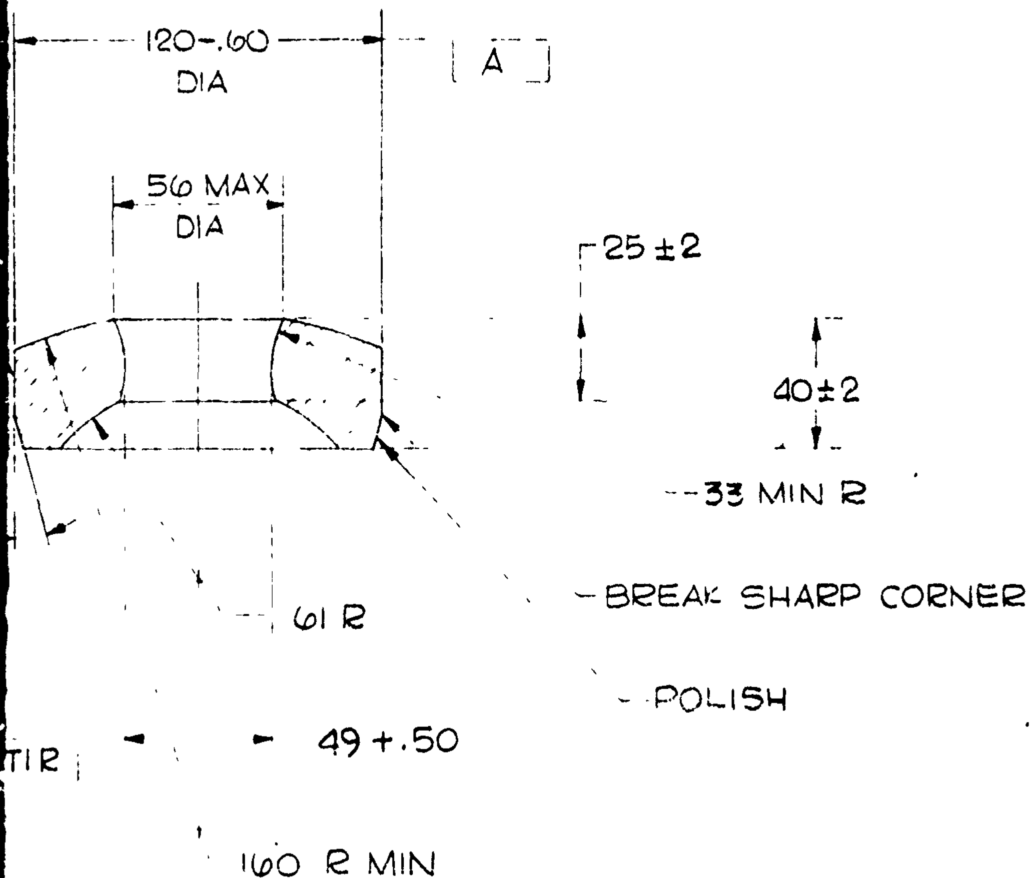
DECIMALS ±

FRACTIONS ±

3	2	1

REVISIONS

ZONE	SYM	BY	SCRIPTION



2

.01 MM
LISHED
WISE NOTED
ANY CHIPS OR
AN 18X EYEGLASS

REQD	PART NO	DESCRIPTION	STOCK SIZE	MATL	MATL

LIST OF MATERIAL

NEXT ASSY / USED ON	MATERIAL: SEE TABLE	DATE: 14 APR, 1961
APPLICATION	HEAT TREATMENT	DRAFTSMAN: PRS
DIMENSIONS ARE IN INCHES	FINAL PROTECTIVE FINISH	CHECKER
UNLESS OTHERWISE SPECIFIED		ENGR
TOLERANCES / SURFACE FINISH		ENGR
ANGLES ± / DECIMALS ± / FRACTIONS ±		APPROVAL

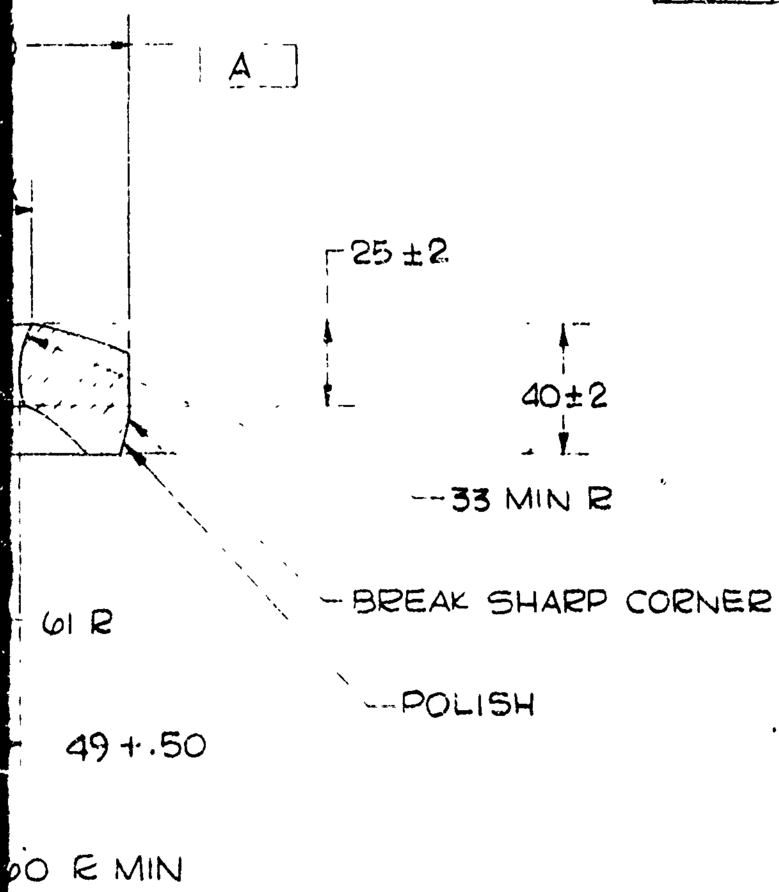
ENDSTONE
JEWEL

MILITARY PRODUCTS DIV.,
HAMILTON WATCH CO.,
LANCASTER, PA

SCALE 50/1 | UNIT WT ACT CALC | DWG SIZE B 11x17 | DRAWING 2 | SHEET

3	2	1

REVISIONS						
ZONE	SYM	BY	DESCRIPTION	DATE	CHKD	APPD



3

REQD	PART NO	DESCRIPTION	STOCK SIZE	MATL	MATL SPEC	REV	ZONE
LIST OF MATERIAL							

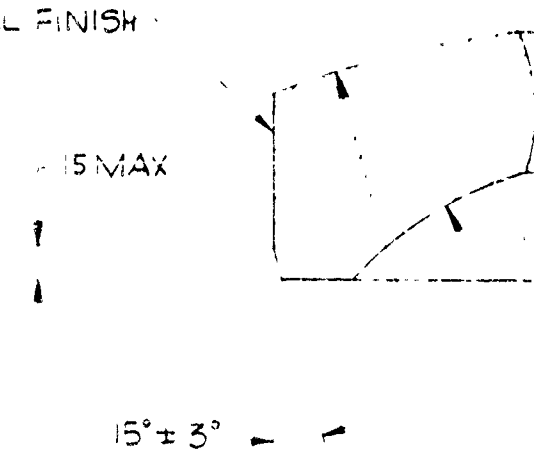
MATERIAL	SEE TABLE
HEAT TREATMENT	
FINAL PROTECTIVE FINISH	
DATE	14 APR, 1961
DRAFTSMAN	
CHECKER	
ENGR	
ENGR	
APPROVAL	
NEXT ASSY / USED ON	
APPLICATION	
DIMENSIONS ARE IN INCHES	
UNLESS OTHERWISE SPECIFIED TOLERANCES: ANGLES ± DECIMALS ± FRACTIONS ±	SURFACE FINISH √

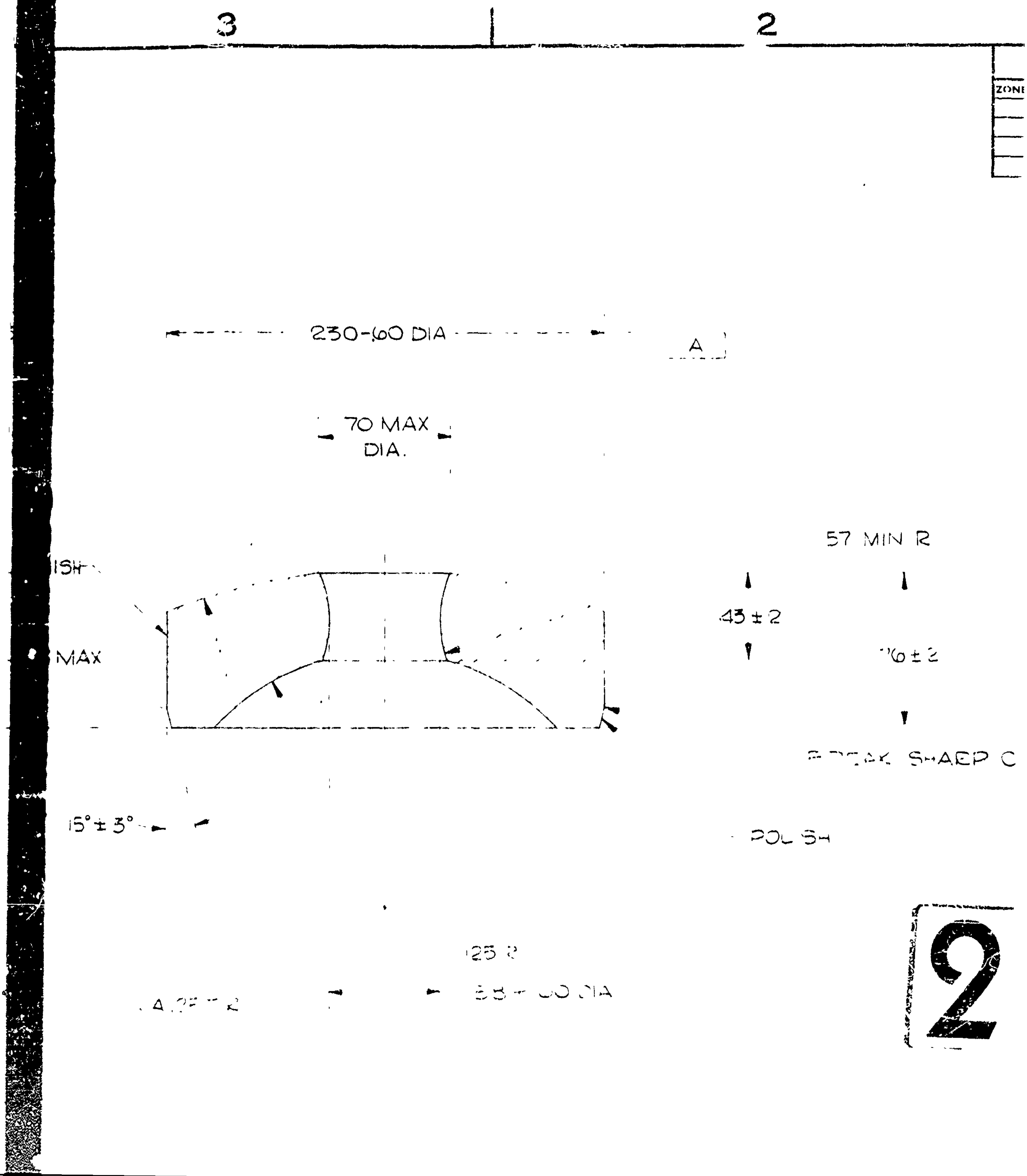
ESAPEMENT PINION #1 JEWEL

MILITARY PRODUCTS DIV.,
HAMILTON WATCH CO.,
LANCASTER PA

SCALE	DWG SIZE	DRAWING NO
50/1	B	21303
UNIT WT. ACT	11x17	SHEET OF 1 REV

JEWEL	MATERIAL
A	SYNTHETIC SAPPHIRE
B	GLASS




3
2
ZONE
230-60 DIA
A
70 MAX
DIA.
57 MIN R
43 ± 2
MAX
15° ± 3°

2 1

REVISIONS

ZONE	SYM	BY	DESCRIPTION	DATE	CHKD	APP'D

D

A

57 MIN R

43 ± 2

76 ± 2

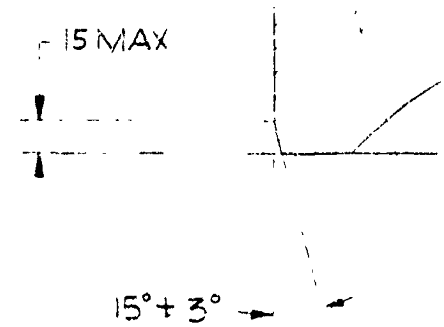
C

BREAK SHARP CORNER

POLISH

3

C



⊚A .25 T.I.R.

B

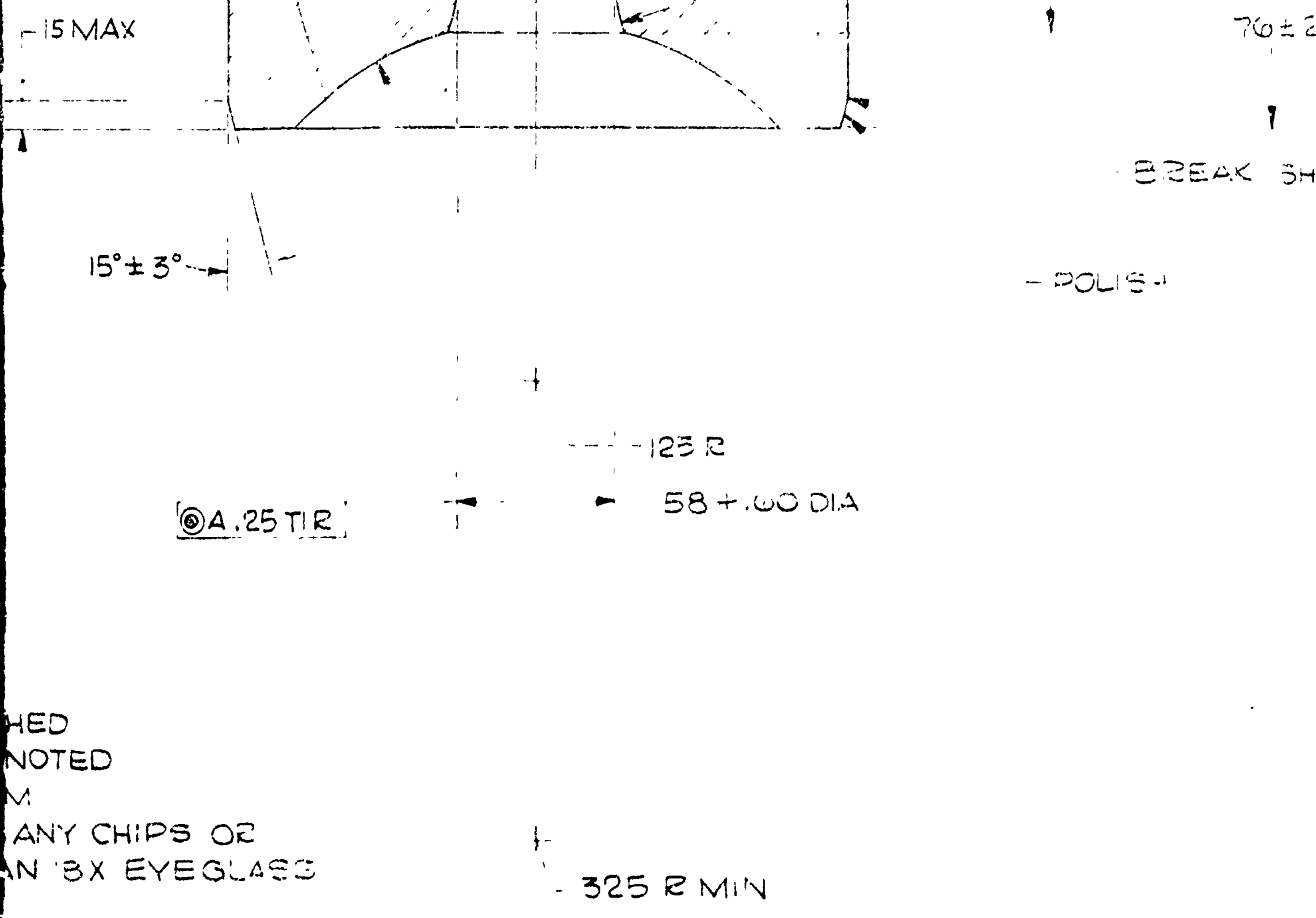
NOTES

1. ALL SURFACES TO BE POLISHED EXCEPT WHERE OTHERWISE NOTED
2. ALL DIMENSIONS ARE IN .01 MM
3. OLIVE HOLE TO BE FREE OF ANY CHIPS OR SCRATCHES VISIBLE WITH AN 8X EYEGLASS

A

4

4 | 3

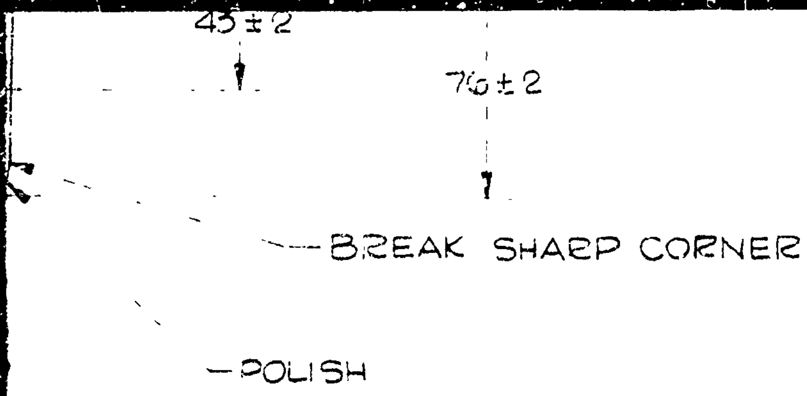


5

REQD	PART NO		DESCR
			MATERIAL
			HEAT TREAT
NEXT ASSY			FINAL NOTE
APPLICATION			
DIMENSIONS ARE IN INCHES			
UNLESS OTHERWISE SPECIFIED			
TOLERANCES ANGLES ± DECIMALS ± FRACTIONS ±	SURFACE FINISH		

3

2



C

B

6

REQD	PART NO	DESCRIPTION	STOCK SIZE	MATL	MATL SPEC	REV	ZONE

LIST OF MATERIAL

MATERIAL: SEE TABLE

HEAT TREATMENT

FINAL PROTECTIVE FINISH

DATE: 20 APR 1961

DRAFTSMAN: PRS

CHECKED

ENGR

ENGR

APPROVAL

#2 PINION JEWEL

A

NEXT ASSY | USED ON

APPLICATION

DIMENSIONS ARE IN INCHES

UNLESS OTHERWISE SPECIFIED

TOLERANCES: ANGLES ± / DECIMALS ± / FRACTIONS ±

SURFACE FINISH

MILITARY PRODUCTS DIV.,
HAMILTON WATCH CO.,
LANCASTER PA

SCALE 50/1

UNIT WT: ACT / CALC

DWG SIZE: C 7x22

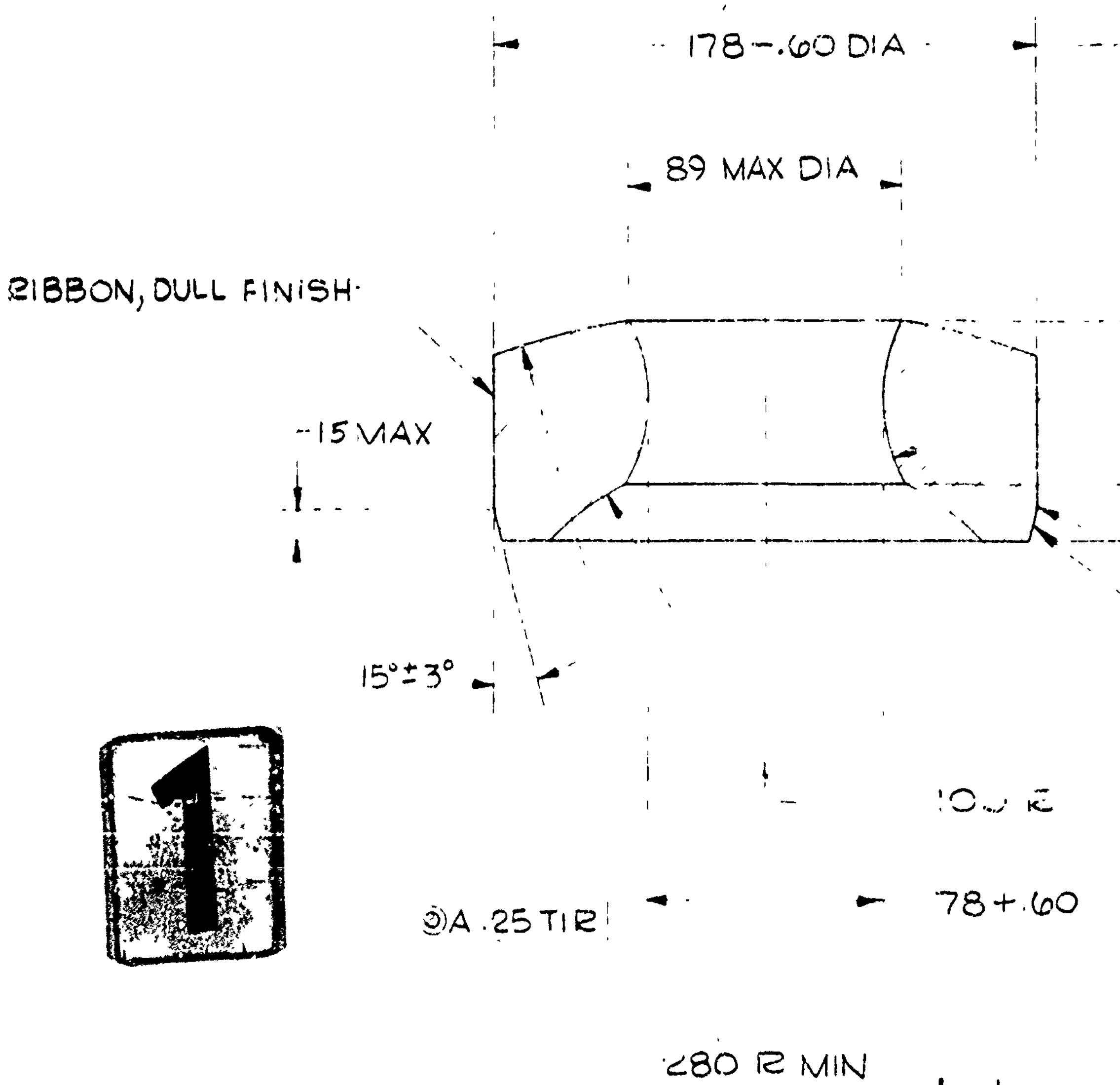
DRAWING NO 21304

SHEET 1 OF 1

REV

2 1

JEWEL	MATERIAL
A	SYNTHETIC SAPPHIRE
B	GLASS



NOTES
1. ALL DIMENSIONS ARE IN .01 MM
2 ALL SURFACES TO BE POLISHED EXCEPT WHERE OTHERWISE NOTED
3 OLIVE HOLE TO BE FREE OF ANY CHIPS OR SCRATCHES VISIBLE WITH AN 18X EYEGLASS

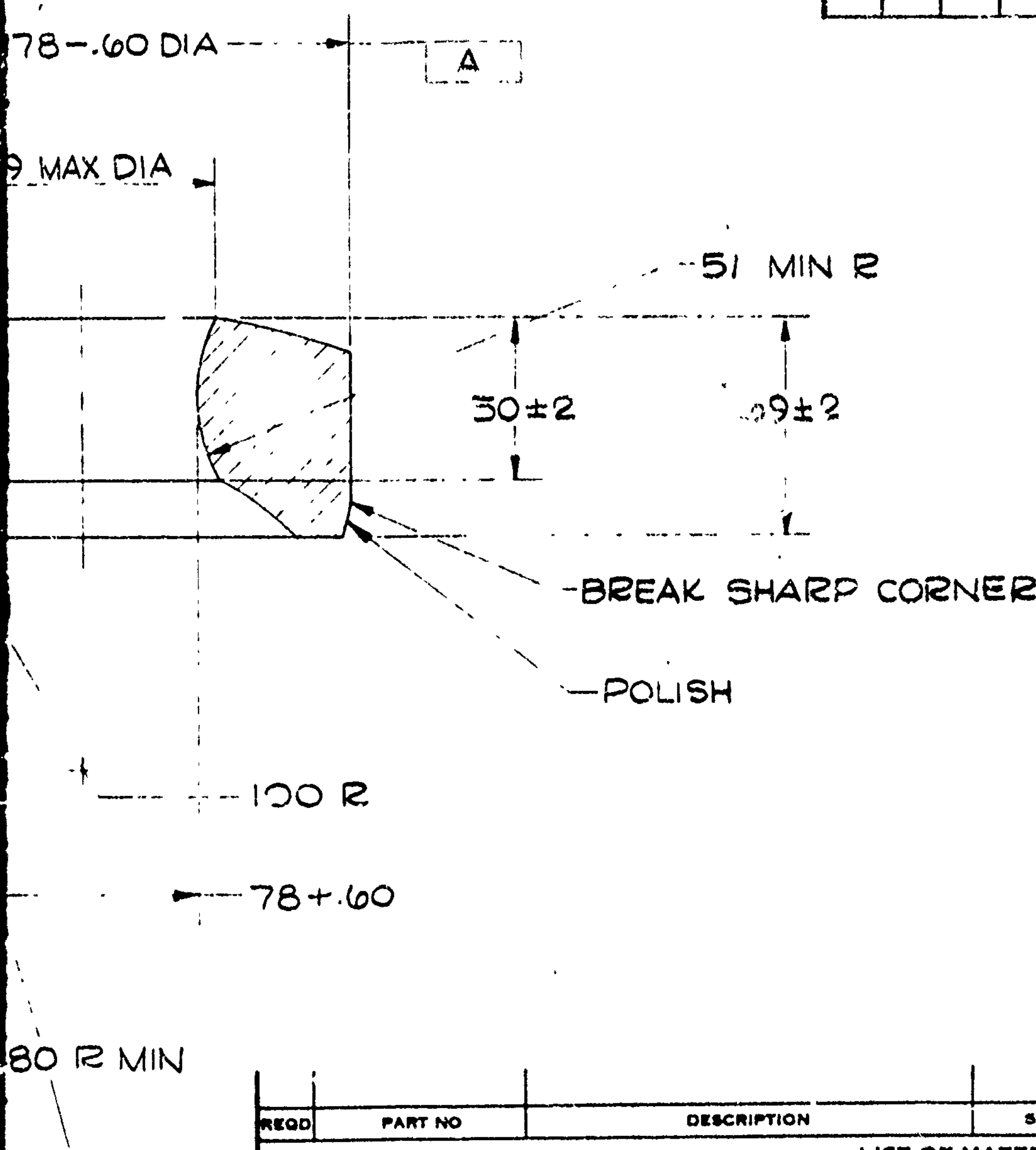
REQD	PART

NEXT ASSY
APPLI
DIMENSIONS
UNLESS OTHER
TOLERANCES
ANGLES ±
DECIMALS ±
FRACTIONS ±

3	2	1

REVISIONS

ZONE	SYM	BY	DESCRIPTION	DATE



2

NOTED
HIPS OR
EYEGLASS

REQD	PART NO	DESCRIPTION	STOCK SIZE	MATL	MATL SPEC

LIST OF MATERIAL

NEXT ASSY	USED ON
APPLICATION	

DIMENSIONS ARE IN INCHES
UNLESS OTHERWISE SPECIFIED

TOLERANCES — SURFACE FINISH
ANGLES ±
DECIMALS ±
FRACTIONS ± / √

MATERIAL: SEE TABLE
HEAT TREATMENT
FINAL PROTECTIVE FINISH

DATE: 19 APR 1961
DRAFTSMAN: FJS
CHECKED
ENGR
ENGR
APPROVAL

#3 & #4 PINION JEWEL

MILITARY PRODUCTS DIV.,
HAMILTON WATCH CO.,
LANCASTER, PA.

SCALE 50/1
UNIT WT. ACT CALC
DWG SIZE B 11x17
DRAWING NO. 2130
SHEET 1 OF 1

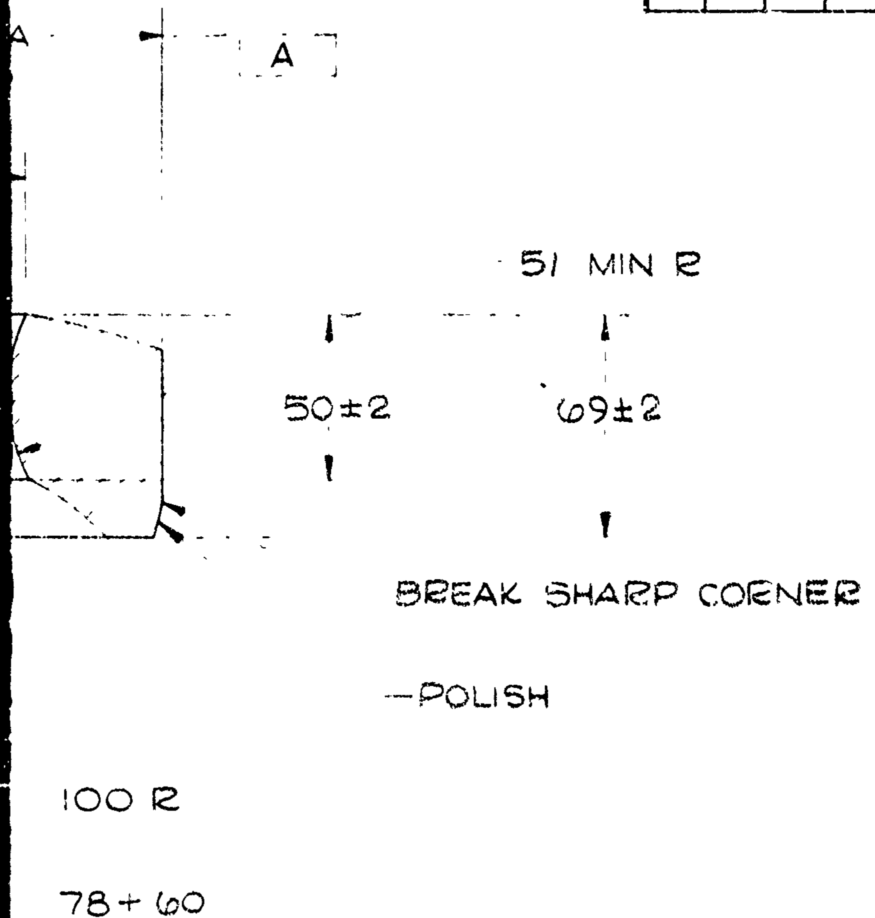
3	2	1

2 1

REVISIONS

ZONE	SYM	BY	DESCRIPTION	DATE	CHKD	APPD

B



3

A

RECD	PART NO	DESCRIPTION	STOCK SIZE	MATL	MATL SPEC	REV	ZONE

LIST OF MATERIAL

NEXT ASSY	USED ON

APPLICATION

DIMENSIONS ARE IN INCHES

UNLESS OTHERWISE SPECIFIED

TOLERANCES: ANGLES ± / DECIMALS ± / FRACTIONS ±

SURFACE FINISH √

MATERIAL: SEE TABLE

HEAT TREATMENT

FINAL PROTECTIVE FIN

DATE: 19 APR 1961

DRAFTSMAN

CHECKER

ENGR

ENGR

APPROVAL

#3 & #4 PINION JEWEL

MILITARY PRODUCTS DIV
HAMILTON WATCH CO.
LANCASTER, PA

SCALE 50/1

UNIT WT ACT

DWG SIZE B 11x17

DRAWING NO 21305

SHEET 1 OF 1

REV

1 2 1